tional area of the tube **54** matches that of the vane **40**. Likewise the cross sectional area through the transition portion **62** is kept constant to match that of the tube **54** and the vane **40**. The cross sectional area of the porous structure **58** is also kept constant through the vane **40**, transition portion **62**, and the tube **54**. FIGURES 4, 5, and 6 show the cross section of the vane **40**, the tube **54**, and the transition area **62**, respectively.

The porous structure **58** is continuous from the forward end of the tube **54** to the inner end of the vane **40** and is of a controlled porosity, that is, the diameter of the pores in the porous structure increase from the vane end of the forward tube end. This controlled porosity is shown schematically in FIGURE 7 with which the principle of operation of the closed heat transfer circuit will be explained.

Referring now to FIGURE 7, there is shown an ordinary closed elongated cylindrical chamber of constant cross section which corresponds to tube **54**, transition **62**, and vane **40** of FIGURE 1. The chamber contains a porous capillary structure which extends its entire length and corresponds to the porous structure **58**. The porous structure is of a controlled porosity, that is, the diameter of the pores decrease from the left end to the right end. In making the chamber, it is first filled with a liquid heat transfer medium such as sodium until the porous structure is slightly over saturated. The chamber is then evacuated and sealed so that only the heat transfer medium is present within the tube and at a subatmospheric pressure. The heat transfer medium thus is in both the liquid state and the vapor state; the porous structure being substantially saturated with liquid sodium while the remainder of the chamber is filled with sodium in the vapor state. When the right end of the cylinder is placed in a hot environment such as the vanes **40** in the turbine inlet and the left end is placed in a relatively cool environment such as the end of tube **54** in an area subjected to compressor discharge air, the following phenomena will take place. While the compressor discharge air may be on the order of 500–600° F., it is relatively cool compared to turbine vane temperatures on the order of 1700–1800° F. The vapor in the right end will be at a pressure $P_2$ which is higher than the pressure $P_1$ of the vapor at the left end because the vapor in the right end is at a higher temperature. Also as shown, the right end is at a higher potential energy level $h_2$. The result is that the vapor flows from right to left or from the evaporator to the condenser. While as illustrated the vapor flow will be aided by the difference in potential energy, it is to be understood that this difference is not required. The tube may be at one equal level or the vapor may be required to flow uphill, that is, $h_1 \geqslant h_2$. In the turbine application, this corresponds to vapor flow from the vanes **40** to the upstream end of the tubes **54**. At the left end, the vapor is condensed into the capillary porous structure as a liquid. The pressure of the liquid at the left end, however, is somewhat lower than that of the vapor. The pressure drop through the meniscus having a radius $r_1$ equal to or greater than the capillary pore size at that point is $2^{\gamma}/r_1$ where $\gamma$ is the surface tension. Correspondingly, the pressure in the liquid at the right end is

$$P_2-\frac{2\gamma}{r_2}$$

A positive pressure drop to drive the liquid from the condenser to the evaporator may be created by controlling the porosity of the capillary structure. That is,

$$P_1-\frac{2\gamma}{r_1}+\rho g h_1$$

(where $\rho$ is the liquid density and $g$ is the acceleration due to gravity) must be greater than

$$P_2-\frac{2\gamma}{r_1}+\rho g h_2$$

even though both $P_2$ and $h_2$ are greater than $P_1$ and $h_1$. Expressed mathematically:

$$\frac{r_1-r_2}{r_1 r_2}\ \frac{(P_2-P_1)+\rho g(h_2-h_1)}{2\gamma}$$

This can obviously be done from the above equation by making $r_1$ or the pore diameters at the left or condenser end larger than the pores at the evaporator end. While we have considered only the end points, the same relationship holds for the intermediate points resulting in the requirement of a progressively increasing pore diameter from the evaporator to the condenser end. When this is done, the porous capillary structure will flow the liquid from the condenser end to the evaporator end even though the pressure in the vapor at parallel points causes the vapor to flow in the opposite direction and even though the liquid must flow uphill. When the liquid reaches the right end corresponding to the vane **40** of FIGURE 1, heat is absorbed from the vane walls evaporating the liquid inside and cooling the vane. The vapor thus driven out of the porous structure is at pressure $P_2$ and will flow to the left or condenser end to repeat the heat transfer cycle. Thus the circulating heat transfer media cools the vanes **40** efficiently and transfers the heat to the compressor discharge air. This is a regenerative effect and as such is beneficial to the engine since adding heat to the compressed air at this point less the requirement for heat addition by combustion. Fuel may be saved and the engine specific fuel consumption consequently lowered.

Thus it can be seen that this invention provides a guide vane ring provided with a closed circuit cooling system which provides a two-fold benefit. First its primary purpose, that is, cooling of the vanes is fulfilled by a system which is simple and requires no pump or other moving parts. Secondly, it fulfills this purpose in a manner which is beneficial to the engine, that is, gives a regenerative effect to improve the engine fuel consumption.

It should be understood, of course, that the foregoing disclosure relates to only a preferred embodiment of the invention and that numerous modifications or alterations may be made therein without departing from the spirit and scope of the invention as set forth in the appended claims.

What is claimed is:

**1.** In a gas turbine having compression, combustion, and turbine zones in serial relationship, the combination comprising:

guide vane means in said turbine zone exposed to hot combustion gases flowing through said turbine zone,

a plurality of circumferentially spaced closed tubes extending axially from said guide vane means to an area subjected to compressor discharge air,

wick means disposed in said tubes and said guide vane means, and

a heat exchange medium substantially filling said tube and said guide vane means, a portion of said heat exchange medium being in the liquid state and saturating said wick means with the remainder being in a vapor state whereby a closed system is provided to transfer heat from said guide vane means to said compressor discharge air to cool said guide vane means.

**2.** In a gas turbine having compression, combustion, and turbine zones in serial relationship, the combination comprising:

guide vane means in said turbine zone exposed to hot combustion gases flowing through said turbine zone,

a plurality of circumferentially spaced closed tubes extending axially from said guide vane means to said compression zone,

porous means disposed in said tubes and said guide vane means, said porous means extending continuously and having pores of progressively increasing diameter from said guide vane means to the upstream end of said tube,